# SIMULATION ON AIR CONDITIONING USING FUZZY LOGIC

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## ABSTRACT

Air conditioning systems are integral part of almost every institution. It contributes significant part of total energy consumption. Studies suggest that in locations like class rooms, hall and offices in UMP, air conditioning can contribute as much as 75% of total energy intake. Even in homes and offices, power consumed by air conditioners is significant. Fuzzy logic is actually one of the artificial intelligence techniques that being used widely in development system nowadays. Simulation on Air Conditioner Using Fuzzy Logic is a stand-alone system that enable user to display the simulation of air conditioner spinning fan. This system is made for UMP's staff or lecturer to simulate how the fan is spin according to the temperature. The system has been successfully developed within time and user can display the output of the percentage of the fan speed based on two inputs that are set_temp and current_temp. The simulation is shown based on the inputs and output calculated using Fuzzy Logic technique.

## ABSTRAK

Sistem penghawa dingin memaikan peranan sebahagian besar kepada setiap institusi. Ia menyumbang sebahagian besar daripada jumlah penggunaan tenaga. Kajian menunjukkan bahawa di lokasi seperti bilik kelas, dewan dan pejabat-pejabat di UMP, penghawa dingin boleh menyumbang sebanyak 75% daripada jumlah pengambilan tenaga. Walaubagaimanapun di rumah dan pejabat, kuasa yang digunakan oleh penghawa dingin adalah penting. *Fuzzy Logic* sebenarnya adalah salah satu teknik yang digunakan secara meluas dalam sistem pembangunan pada masa kini. Simulasi Sistem Penghawa Dingin yang menggunakan *Fuzzy Logic* adalah satu sistem yang berdiri sendiri yang membolehkan pengguna untuk memaparkan simulasi kipas penyaman udara berputar. Sistem ini dibuat untuk kakitangan atau pensyarah UMP untuk mensimulasikan bagaimana kipas berputar mengikut perubahan suhu. Sistem ini telah berjaya dibangunkan dalam masa yang ditetapkan dan pengguna boleh memaparkan yang keputusan peratusan kelajuan kipas berdasarkan dua input iaitu set_temp dan current_temp. Simulasi akan ditunjukkan berdasarkan input dan keputusan yang dikira menggunakan teknik *Fuzzy Logic*.

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# CHAPTER I

# INTRODUCTION

This chapter briefly discussed on the overview of this research. It contains five sections. The first sections are introduction then follow by the problem statements. Next are the objectives where the project's goal is determined. After that are the scopes of the system and lastly is the thesis organization which briefly describes the structure of this thesis.

## 1.1. Background

An air conditioner is a home appliance, system or machine that builds to extract heat air to turn it into a cool air. Nowadays, lots of air conditioner use fuzzy logic, for example Mitsubishi Air conditioner.

Conventional air conditioning systems use on-off controllers. When the temperature drops below a preset level the unit is automatically turned off. When the temperature rises above a preset level the unit is turned on. The former preset value is lower than the later preset value, providing a dead zone, so that high-frequency on-off cycling is avoided. The thermostat in the system controls the on-off action. For example, when the temperature rises to 25°C, turn on the unit, and when the temperature falls to 20°C, turn off the unit.

The Mitsubishi air conditioner controls by using fuzzy rules such as, IF the air is getting warmer THEN turn the cooling power up a little AND IF the air

is getting cold, THEN turn the power down moderately. The machine becomes smoother as a result. This means less wear and tear of the air conditioner, more consistent comfortable room temperatures, increased efficiency and energy savings.

The same technique is going to be show using simulation that will be develop to be apply to University Malaysia Pahang's class rooms or Lecture Hall (*Dewan Kuliah*). The simulation will show how the speed of the fan rotates accordingly to the temperature that is set by user, and the current room temperature of the rooms or halls.

## 1.2. Problem Statement

There are few problems that need to be concern. One of the problems is when students having an examination for example in Lecture Hall, they will complain to the staff or the lecturer that the hall is too cold and they cannot concentrate to answer the paper well. The staff or the lecturer will find it difficult to increase the temperature because the air conditioner is already set to 20˚c.

The other problem is the government has issue an order to maintain the temperature of the air conditioning to 24˚c. If there are only few students in the hall, the temperature should be increase to avoid students from froze and if there are too many students in the hall, the temperature should be decrease suitably according to total of students. It is hard only to maintain the temperature. It has to adapt based on the current hall temperature and the set temperature in the hall or class rooms.

## 1.3. Objective

The objectives of the project are:

i. To develop a prototype to simulate an air conditioner.

ii. Apply fuzzy logic technique to the simulation.

## 1.4. Scope

The scope for the project is:

i. Classes, halls and offices in University Malaysia Pahang that uses air conditioner system.
ii. The inputs for the simulation are current temperature, and set temperature.
iii. The output for the simulation is increasing or decreasing of the air conditioner fan speed.

## 1.5. Thesis Organization

This thesis consists of four (4) chapters. Chapter one (1) is Introduction. Explanation of introduction to the system. In this chapter, system overview, problem statements, objectives and scope of the project is disscussed.

Chapter two (2) is Literature Review that will discuss more on the research about the project that has been chosen. The research is divided into two, that is current system or case study and research for technique that will be used to develop the current system.

In Chapter three (3) is Methodology of overall work load to develop this system will be disscuss. The content consists of the approach and framework for the project that used in the system also the implementation of the process that is involved during development of this system.

Lastly in chapter four (4) is the Conclusion. In this chapter, briefly summarize all the chapters involve and the results or outputs that obtained from the implementation of the system is discussed thoroughly. The constraints of this project are also stated clearly.

# CHAPTER II

# LITERATURE REVIEW

This chapter is to explain about reviews for this project. It is divided to two major parts: system/present review and technique, method, equipment, as well technology review.

## 2.1 Current Practice in University Malaysia Pahang (UMP)

This section is reviewed the current practice system on fuzzy logic control of air conditioner were adapt in UMP.

### 2.1.1 Fuzzy Logic Control of Air conditioners in WDK, UMP

An interview has been conducted with Mr. Azizan b. Jernia, Assistant Mechanical Department. There are several class rooms that have different types and total of air conditioner. A system have been develop for air conditioning control in WDK block where it is been

monitored through a computer in a control room. This system is still under supervision and tested within 70% – 80% in a month. On-Off control is in the control room that means, even there is an air conditional remote control in the class, students or lecturer cannot change the temperature because it has been set default to 24˚C in the system. The air conditioner used is Acson that have fuzzy logic technology built in.

## 2.2. Article about Setting the Temperature of Air Conditioner to 24˚C

Minister of Energy, Green Technology and Water, Datuk Seri Peter Chin Fah Kui, an act will be drafted to enact the existing Acts and it is expected to be enforced by 2013. The Prime Minister has ordered a good move to reduce or to provide energy efficiency and all government buildings will be required to raise the temperature setting for government buildings through a circulars letter that will be issued by the Secretary of State.

In the article, the Prime Minister has said that 24˚ Celsius is the appropriate temperature level in this country compared to China, who placed 26˚ Celsius for their government buildings. However, exemption is granted to the government buildings that have a specific reason such as a in hospital that are operating room and intensive care unit (ICU) that need temperature lower than 24˚ Celsius. [21]

## 2.3. Existing Systems Review

This section is reviewed the current system and the existing system that related to simulation of fuzzy rules for air conditioning.

### 2.3.1. Fuzzy Logic Control of Air Conditioners

Most of the air conditioning nowadays has adapted the fuzzy logic technology. By adapting the fuzzy logic control (FLC), temperature can be control well. Cost and time consuming can be save also goes to electrical energy intake of the AC compressor/Fan while utilizing all available resources in the most efficient manner using fuzzy logic control (FLC). Three variables were used that are user temperature preference, actual room temperature and room dew point temperature. User temperature is subtracted from actual room temperature before being sent for fuzzyfication. Fuzzy arithmetic and criterion is applied on these variables and final result is defuzzyfied. The Fuzzy logic system is used to design the algorithm. [1]

Software to make use of these FCL files is written in C++ using Free Fuzzy Logic Library (FFLL), an open source fuzzy logic class library and API. Simulation is also done in MATLAB. [2]

Use of FLC system in combination with LON (Local Operation Network), technology for control and power management of air conditioning systems increases the exchange of control information of the system. Using variable speed operated pumps for the heat exchangers reduces enormously the electrical power consumption of the pump during the control mode of the system. The control information exchange system provided by LON works ensures that only one of the actuators executes the control task within the scan time cycle, which is important for robust control. [3]

### 2.3.2. Fuzzy Logic Control for Vehicle Air Conditioning System

Vehicle also adapts the fuzzy logic control technology. Few studies have been made about the fuzzy logic control for vehicle. Measurements to study the vehicle air conditioning are time interval of one minute for a set point temperature of 22, 23 and 24˚C with internal heat loads of 0, 1 and 2kW. The main objective of the study was to evaluate the energy saving obtained when the fuzzy logic control (FLC) algorithm continuously regulates the compressor speed. It was proved that the experiment is successful, energy can be saved and indoor comforts were improved compared to the conventional (On/Off) control technique. [4]

A practical application of a fuzzy control system for a non-linear air conditioning system in the automobile was simulate and the results are gathered. Temperature control in an automobile passenger environment is more complex than that of a static room in a building. With regards to both driver and passenger comfort and safety, a lot of factors must be taken. The objective of the paper is to study the implementation of fuzzy logic control in automobile climate control system compared to the existing state flow controller. [5]

### 2.3.3. Traffic Light Controller

Traffic congestion is the main thing that worries people around the world. By developing a sophisticated traffic and more effective monitoring and control system that is effective, it can help solve this problem. In the conventional traffic light controller, traffic lights change at constant cycle time. It does not provide an optimal solution. Traffic light controller based on fuzzy logic can be used for optimal control of

variable volume overload, such as the saturated conditions or unusual. Objective is to increase the vehicle throughput and minimize delays to the public. [6]

When the numbers of road user constantly increase, and resources provided by current infrastructures are limited, intelligent control of traffic will become a very important issue in the future. However, some limitations to the usage of intelligent traffic control exist to avoiding traffic jams. Three series of experiments was performing with using the green light district traffic simulator. The first experiment, which uses a large grid, shows that reinforcement learning is efficient in controlling traffic, and that the use of co-learning further improves performance. The second experiment shows that using co-learning vehicles avoid crowded intersections. This way, vehicles avoid having to wait, and actively decrease pressure on crowded intersections. The third experiment shows that RL algorithms on more complex and city-like infrastructure again outperform the fixed controllers by reducing waiting time with more than 25%. The third experiment also shows that in some situations a simplified version of the reinforcement learning algorithm performs as well as the complete version, and that co-learning not always increases performance. [7]

This journal presents a fuzzy logic-based adaptive traffic signal controller for an isolated intersection. The controller has the ability to make adjustments to signal timing in response to observed changes in the approach flows. Using upstream vehicle detectors, the controller measures approach flows and estimates approach queues at regular time intervals. This information is used in a fuzzy logic procedure to determine, at any given time, whether to extend or terminate the current signal phase for through movements. In the first stage, the controller

estimates the traffic intensity on each approach. The duration of the green is based on traffic-actuated control. [8]

### 2.3.4. Water Level Control

Synthesis water level control by fuzzy logic focuses on evolving of two type that are fuzzy and classical Proportional, Integral and Derivative(PID) liquid level controller and examining whether they are better able to handle modeling uncertainties. A two stage strategy is employed to design the synthesis fuzzy and classical PID controller with the process of the first and second order and implement s disorder quadratic function.[9]

It is proved that fuzzy logic controller is useful in applications of nonlinear static characteristic, where classical methods with usually classical PID controllers cannot be a satisfactory outcome. Fuzzy controller allows the user apply their knowledge of the problem and transfer it to an appropriate system environment, which is close to the human way of thinking (liquid level tank control). Fuzzy PID controller in a liquid level control process applications was proved as a very good choice, because the planning process of fuzzy controller is relatively simple and suitable for engineering practice. [10]

An optimization method for the operation of conditioning system is achieved by fuzzy control system and implemented automation system. The fuzzy control system determines required water ratio precisely to regulate the temperature instead of using trials for adjusting the water ratio when applying conventional control. It is an important factor of the given control system eventually reaches an equilibrium state, after which the temperature barely needs to be adjusted anymore. A conventional control method causes the waste of hot or cold water, which means not optimal utilization of energy. The fuzzy logic control

means: accuracy of temperature control and saves energy by rationing the cold or hot water streaming. [11]

One of the most important elements in lawn maintenance is the moisture adequacy. For this reason, irrigation, done by manual or automated sprinkler system, has been applied. However, both systems may use excessive amount of water and the amount dispersed may not be suitable for the moisture level of the lawn. Therefore, there is a need to develop an irrigation system that can measure and monitor the soil moisture through data acquired from the soil and also from the climatologic factors that will help to decide when to water and how much water is needed. Once the actual rules and fuzzy sets are determined, the comparison of the conventional irrigation system with all four fuzzy inference methods was conducted with each other. [12]

### 2.3.5. Fuzzy Logic in Lift / Elevator System Control

Fuzzy logic approach is used to control elevators used in tall buildings. The method of fuzzy logic control of the elevators will be provided economically.. Time and energy can be save and will be provided by providing the elevator first, 49th and then 1st floor coming down. Performance criteria and conditions of the building as a result of fuzzy inference by examining the characteristics of the current directed to the appropriate cabinet. The fuzzy logic controlled studies on this subject before new ones are added to the linguistic variables, the system will control operation of certain time periods during the day differentiated human interpretations and experiences of the effects of fuzzy control algorithm was investigated. The system is given to mathematical calculations, priority call routing function and the elevator cab to a cab floor system call for each coefficient indicating the

importance of proximity to fuzzy logic is described extraction method. [13]

Implement fuzzy logic controller (FLC) on a Field-programmable Gate Array (FPGA) system for intelligent control of elevator system. The approach is based on algorithm which is developed to reduce the amount of computation required by focusing only on the relevant rules and ignoring those which are irrelevant to the condition for better performance of the group of elevator system. Simulation was carried out by considering two inputs i.e. elevator car distance and number of stops. Based on these data the Fuzzy Controller can calculate the Performance Index (PI) of each elevator car and the car which has maximum PI gives the answer to the hall calls. This would facilitate reducing the average waiting time (AWT) of the passenger. [14]

### 2.3.6. Fuzzy Logic Control of Washing Machine

Fuzzy logic control has enabled to obtain a wash time for different type of dirt and different degree of dirt. The conventional method required the human interruption to decide upon what should be the wash time for different cloths. In other words this situation analysis ability has been incorporated in the machine which makes the machine much more automatic and represents the decision taking power of the new arrangement. The fuzzy controller takes two inputs that are degree of dirt and type of dirt processes the information and outputs a wash time. How to get these two inputs can be left to the sensors (optical, electrical or any type). [15]

### 2.3.7. Fuzzy Logic Real World Example

Most of big companies such as Panasonic, Hitachi, Canon and Mitsubishi have applied Fuzzy logic into their product. For air conditioner, Fuzzy Logic was used to control the temperature based on certain rules that has been set while for vacuum fuzzy control is adapt together with microprocessor to detect dust based on condition of the floor. Famous use of fuzzy logic is washing machine where the control system senses both quality and quantity of dirt, load size, and fabric type, and adjusts the washing cycle and detergent amount accordingly. Television (Sony): A fuzzy logic scheme uses sensed variables such as ambient lighting, time of day, and user profile, and adjusts such parameters as screen brightness, colour, contrast, and sound. There are lots more product that uses fuzzy logic nowadays. [16]

Soft computing (SC) is an evolving collection of methodologies, which aims to exploit tolerance for imprecision, uncertainty, and partial truth to achieve robustness, tractability, and low cost. Fuzzy logic (FL), neural networks (NN), and evolutionary computation (EC) are the core methodologies of soft computing. However, FL, NN, and EC should not be viewed as competing with each other, but synergistic and complementary instead. Soft computing is causing a paradigm shift (breakthrough) in engineering and science fields since it can solve problems that have not been able to be solved by traditional analytic methods [Tractability (TR)]. In addition, SC yields rich knowledge representation (symbol and pattern), flexible knowledge acquisition (by machine learning from data and by interviewing experts), and flexible knowledge processing (inference by interfacing between symbolic and pattern knowledge), which enable intelligent systems to be constructed at low cost [high machine intelligence quotient (HMIQ)]. This paper reviews applications of SC in several industrial fields to show the various

innovations by TR, HMIQ, and low cost in industries that have been made possible by the use of SC. [17]

## 2.4. Tool and Equipment

### 2.4.1. MATLAB/Simulink tool

Most of the existing systems use the MATLAB/Simulink tool to design the prototype system. The existing systems are Development of Fuzzy Logic Control for Vehicle Air Conditioning System, Traffic Light Controller, Fuzzy Logic Control of Air Conditioners Water Level Control, Intelligent Traffic Light Control, Control the Extension Time of Traffic Light in Single Junction, Air-conditioning System, Control for Non Linear Car Air Conditioning, and Water Tank Level Control.

By using MATLAB/Simulink, Fuzzy Logic Toolbox packages and MATLAB programming for stabilizing the water tank level control, it is a simple and easy approach to know more about water level system, including its level movements, valve setting, data consistency, and also about the rules of the variables. [13]

A prototype system for controlling traffic at an intersection is designed using VB6 and Matlab tool. The traffic intersection is simulated in VB6 and the data regarding the traffic parameters is collected in VB6 environment. The decision on the duration of the extension is taken using the Matlab tool. This decision is based on the Arrival and Queue of vehicles, which is imported in Matlab from VB6 environment. The time delay experienced by the vehicles using the fixed as well as fuzzy traffic controller is then compared to observe the effectiveness of the fuzzy traffic controller. [6]

### 2.4.2. Visual Basic 2008 (VB 2008) environment

Function of visual basic 2008 is same with Matlab tool; it is to design the prototype system. Typically, designer uses the Matlab tools to design their prototypes than VB 2008 because Matlab tools easier to use.

A prototype system for controlling traffic at an intersection is designed using VB 2008 and Matlab tool. The traffic intersection is simulated in VB 2008 and the data regarding the traffic parameters is collected in VB 2008 environment. The decision on the duration of the extension is taken using the Matlab tool. This decision is based on the Arrival and Queue of vehicles, which is imported in Matlab from VB 2008 environment. The time delay experienced by the vehicles using the fixed as well as fuzzy traffic controller is then compared to observe the effectiveness of the fuzzy traffic controller. [6]

## 2.5. Techniques

### 2.5.1. Fuzzy Expert Systems

#### 2.5.1.1. Fuzzy Logic

##### 2.5.1.1.1. Fuzzy Set

Fuzzy sets are sets whose elements have degrees of membership. In fuzzy set theory, classical bivalent sets are usually called crisp sets. The fuzzy set theory can be

used in a wide range of domains in which information is incomplete or imprecise, such as bioinformatics. [20]

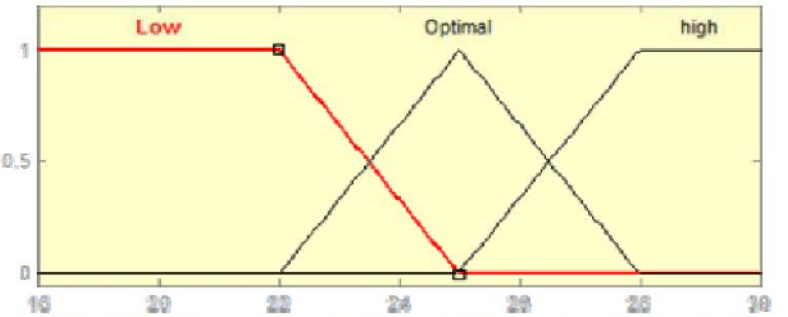

Figure 4 user temperature preference (Ut) membership functions

**Figure 2.1:** Example of Membership Function [2]

### 2.5.1.1.2. Linguistic Variable and Hedges

At the root of fuzzy set theory lies the idea of linguistic variables. A linguistic variable is a fuzzy variable. For example, the statement "John is tall" implies that the linguistic variable *John* takes the linguistic value *tall*.

The linguistic description of expert can be set as rules (IF…THEN). These rules of control system can be written as following:

IF the temperature is mild and the change of temperature is zero THEN the conditioning system must be stopped.